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An experiment to test the consumption of arboreal food by Wood mouse *Apodemus sylvaticus*

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Abstract

Analysed factors affecting the arboreal feeding activity of wintering wood mice in a set of woodlots in central Spain. Stations were baited with acorns on branches, trunk and ground of 429 trees to test the arboreal behaviour of mice. Acorn intake on branches was positively and significantly related to accessibility of food but not to mice abundance. The best predictor of food consumption on branches was, however, the ground-trunk acorn intake, suggesting that this variable was a good index of the scarceness of food. We conclude that morphological constraints in the arboreal ability of the species were evident.

Introduction

Wood mice *(Apodemus sylvaticus)* are recognized as expert climbers (Holisova 1969; Le Louarn and Saint-Girons 1977; Gurnell 1985), but there is a lack of information about the factors determining this behaviour (Montgomery and Gurnell 1985). The use of arboreal substrata may be subject to conflicting factors, such as predation risks, resource availability, and others (e.g. King 1985; Brown 1989; Simonetti 1989). The trade-off between risks and benefits in a particular microhabitat may change, however, as a result of increased pressures on other microhabitats nearby. For example, high population densities may force some individuals to use less preferred resources (Fretwell 1972; Gurnell 1985). Thus, decreased availability of food, frequently related to peak densities (Flowerdew 1985; Hansson 1985), may stimulate the exploratory behaviour of rodents (Stickle 1979; Montgomery and Gurnell 1985; Pennycuik and Reisner 1989). Morphological constraints and travel expenditures seem to be the another relevant factor influencing the selection of feeding microhabitats (Wiens 1973; Gurnell 1985; Brown 1989; Simonetti 1989).

In this work, we explore the incidence of mice abundance and food accessibility on the arboreal feeding activity of wintering wood mice *(Apodemus sylvaticus)* in Holm oak woodlots of central Spain. The winter is a period with heavy food constraints for many temperate endotherms (Newton 1981; Merrit 1984), so mice arboreality could be stimulated in this season.

Study area

The study area is located in Burgos province, central Spain. Average altitude is 850 m and phytoclimatic conditions are inland mediterranean, with long and cold winters (Rivas-Martínez 1981). The area has a deforested agricultural landscape, with extensive cereal cropping and sheep grazing as main usages. Some tracts of the original forests remain, with a dominant vegetation formed by Holm oaks *(Quercus rotundifolia)* and shrubs of the genera *Cistus, Genista, Thymus* and *Lavandula*. These woodlots support wintering populations of wood mouse, but mice are scarce during winter in the surrounding fields (Tellería et al. 1990; see also Alcántara 1986). Previous trapping work showed that rodent species other than wood mice are scarce or absent in these forests; Common voles *(Microtus arvalis)* settle some grassy sectors and Garden dormice *(Eliomys quercinus)* hibernate throughout the winter. Seventeen isolated woodlots, ranging from 0,1 to 280 ha (Table), were studied in order to evaluate the use of arboreal preys by mice.

The 1988 autumn crop of acorn, preceding the study winter, was very scarce; at the start of December only 0.8 % (n = 131) of the Holm oaks beared fruits and 3.2 % (n = 158) had shed acorns to the surrounding ground. By the 20th of January a high degree of depletion was evident, since tree and ground acorns were lacking in most woodlots.

Material and methods

Food accessibility

Holm oak half-acorns were pierced with wire and tied round branches with different diameters and at different distances from the tree basis to test the relationship between the arboreal feeding efficiency of mice and food accessibility. The wood mouse is an omnivore, and includes fruits in its diet (Obrtel and Holisova 1983; Hansson 1985), so that we could assume that Holm oak acorns should be profitable baits. Acorns were arranged during one dark night in each woodlot, and placed and controlled in the same order, so all acorns were exposed the same time. Two experiments were carried out in 1989, from 12 to 16 January and from 2 to 5 February. One half-acorn per tree were tied on 429 trees distributed among the 17 Holm oak forests. Numbers of acorns ranged from 6 to 49 in each experiment (Table), according to a logarithmic function of forest area. Branch diameter was estimated visually for 380 acorns; distance from ground was estimated for each acorn as the shortest path from the base of the tree. Branches ranged from 0.3 to 10 cm in diameter, with the majority between 0.5 and 3 cm (87.9 %). Distances ranged from 0.5 to 12 m, those between 2 and 4 m accounting for 78.5 %. Half-acorns were also placed on the trunk, 1.5 m above ground and on the base of the trunk, in the same trees, to assess the global food searching incidence by mice in each forest.

As wintering mice mainly use underground burrows (Dufour 1978; Montgomery and Gurnell 1985), accessibility of arboreal food should be negatively related to ground distance, and positively to branch diameter for morphological reasons. Since separate analysis of these two variables can produce confounding results, a difficulty index (ID) was estimated for each acorn as the product of distance by the inverse of diameter; ID ranged from 0.2 to 26.7, with values between 0.2 and 6 summing 92.1 %. We calculated mean values of distance, diameter and ID for each forest. Percentages of acorns preyed upon by mice were used as estimates of feeding incidence in the three positions sampled. Acorn use on ground was significantly associated with acorn use on trunks ($r = 0.824$, $p < 0.001$, 15 d.f.), therefore both positions were analysed together. Acorn intakes in January and February were positively correlated ($r = 0{,}78$, $p < 0.001$, 15 d.f.; see Tellería et al. 1990), so both samples were pooled. Preyed acorns were easily recognizable by teeth marks and fecal rests. The acorns preyed by birds or lost were not considered in the analyses.

Mice abundance

At the beginning of March 1989, 213 stations were provided with two snap-traps during two consecutive nights (Smith et al. 1975); number of traps ranged from 12 to 196, according to woodlot area. Abundance indexes were obtained as the number of individuals captured by trap in each forest (Table; see Tellería et al. 1990, for more details on the trapping design). Wood mouse was the only species caught.

Statistical analyses were made according to Sokal and Rohlf (1981) and Zar (1984). Mice abundance and acorn intake rates were arcsin transformed, and distance, diameter and ID values logtransformed.

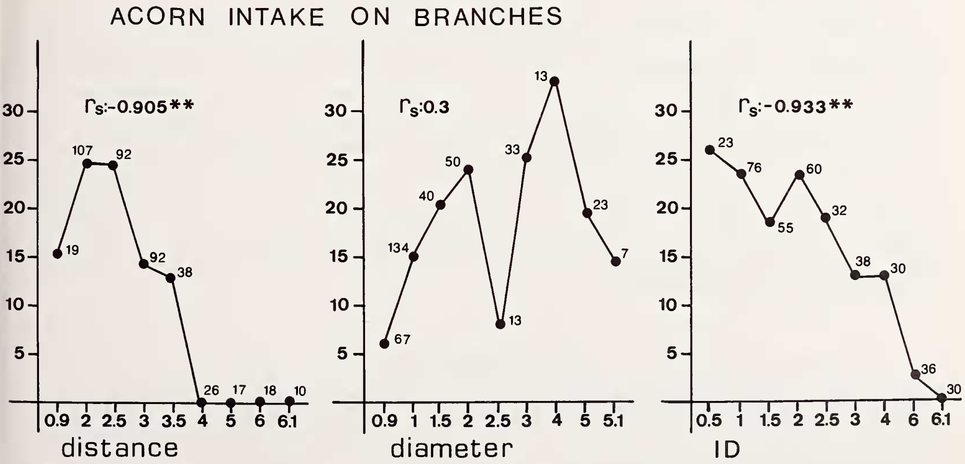
Results

Branch acorns were exclusively preyed upon in locations placed between 0.5 and 3.5 m from the base of the tree; 71 acorns arranged between 3.6 and 12 m remained untouched, most of these placed in the canopy edge. Acorns were consumed from branches of all diameters, although twigs of less than 1 cm supported the lowest predation (see Figure). Relationship between acorn predation rate and accessibility was first explored classifying the acorns in 9 classes according to distance, diameter and ID. The results show that the proportion of preyed acorns decreased significantly with the increase of distance and ID, but a diameter response was not obvious (Figure). ID was the only variable among these three used in the following analyses, since it may be considered a synthetic index representative of acorn accessibility.

Table. **Area, mice abundance (No. individuals/trap × 100), number of acorns placed and controlled (N) and acorn intake rates (percentage of acorns preyed) in each forest**

woodlot area (ha)	mice abundance	acorn intake					
		ground		trunk		branches	
		N	%	N	%	N	%
0.1	17.0	12	(100.0)	12	(83.3)	12	(33.3)
0.3	75.0	12	(91.7)	12	(75.0)	12	(0.0)
0.3	50.0	12	(100.0)	12	(83.3)	12	(41.7)
0.3	50.0	11	(81.8)	10	(80.0)	12	(33.3)
0.3	40.0	12	(83.3)	12	(50.0)	12	(25.0)
0.3	12.5	11	(36.4)	10	(50.0)	12	(0.0)
0.6	33.3	11	(72.7)	11	(72.7)	12	(41.7)
0.7	29.2	12	(75.0)	12	(41.7)	11	(9.1)
0.7	20.8	12	(91.7)	10	(90.0)	10	(45.5)
0.8	33.3	12	(100.0)	12	(100.0)	12	(83.3)
1.2	37.5	12	(66.7)	12	(75.0)	12	(33.3)
1.3	45.8	12	(50.0)	12	(50.0)	12	(16.7)
2.0	29.2	10	(90.0)	10	(80.0)	9	(37.5)
12.0	21.6	49	(44.9)	49	(40.8)	48	(2.1)
16.0	25.0	49	(65.3)	49	(59.2)	49	(32.7)
150.0	2.6	85	(47.1)	85	(12.9)	86	(5.8)
280.0	4.6	89	(38.2)	89	(18.0)	85	(3.5)

According to relationships between the feeding incidence on branches and the independent variables estimated in each forest, ID accounted for more variation ($r = -0.569$, $p < 0.05$; $R^2 = 32.4$ %) than mice abundance ($r = 0.183$, n.s.; $R^2 = 3.3$ %), but this was less than that accountable for acorn intake on ground and trunks ($r = 0.711$, $p < 0.01$; $R^2 = 50.6$ %). These results were supported by partial correlation analyses of feeding incidence on branches with 1) mice abundance and ID: partial r values were 0.287 (n.s.) for abundance and −0.599 ($p < 0.02$) for ID; 2) with mice abundance and ground-trunk acorn intake: $r = -0.299$ (n.s.) and $r = 0.731$ ($p < 0.01$), respectively; and 3) with ground-trunk acorn intake and ID: $r = 0.649$ ($p < 0.01$) and $r = -0.457$ (n.s.), respectively.



Relationships of acorn intake on branches (in percentages) to distance (m), diameter (cm) and acorn accessibility (ID). r_s is the Spearman's rank correlation coefficient; **: $p < 0.01$

Discussion

Mice consumed acorns placed in branches regardless of diameter and up to a distance 3.5 m from the tree base, but not further away. Thus, our results agreed with the arboreality of the species, although a limit in its arboreal exploration was apparent in our study. This could be directly due to constraints in movement ability of mice in trees, but other factors may operate simultaneously (Caraco 1980).

In crowded conditions, some island populations of rodents increase their resource partitioning, with younger individuals obliged to live in suboptimal patches (Gliwicz 1984; see also Lomnicki 1988). Therefore, we should expect a rise of food demands with the increase in mice density in the woodlots studied, and hence a searching increase towards the least accessible acorns. Since this expected relationship did not occur, it is plausible that even the higher densities obtained were very low and mice did not need to explore the most inaccessible acorns; actually, mice abundance accounted for a relatively low variance of the acorns consumed on ground and trunks ($R^2 = 26.2$ %). On the other hand, if resource levels differed among woodlots, the total acorn intake would be a better estimator of trophic stress than mice abundance. In fact, some small woodlots with "low" abundances of mice gave the highest intakes (Table). This view is consistent with our results, suggesting that under conditions of limited food supply mice could search for supplementary food above ground. Also, an increase of searching activity in the adjacent fields, including dispersal behaviour, could be an alternative response. Exploratory and dispersal ability, agricultural field use and habitat tolerance in the Wood mouse (Jonge and Dienske 1979; Jensen 1982; Geuse et al. 1985; Gurnell 1985; Wolton and Flowerdew 1985), suggest that this response would be more profitable than an exploratory increment towards presumably little accessible substrata, such as branches, but at present experimental evidence is lacking.

In conclusion, the findings of our experiment, namely, the clear limit observed in the ability of the Wood mouse to obtain arboreal food, and the association of acorn use on branches with ID, suggest morphological constraints of this species in the searching of tree food, and would indicate a negative yield in the handling of distant arboreal preys. At the same time, this study suggests that mice are capable of overcoming local situations of food scarcity on the ground by using alternative arboreal resources.

In another context, the decreasing gradient observed in the feeding incidence of mice from ground to trunk-branches, implies potential consequences for forest avian species feeding mainly on the ground and trunks (e.g. pariforms; see Ulfstrand 1977). The high densities of mice registered in island conditions in this and other works (e.g. Gliwicz 1984; Geuse et al. 1985), point out a probable competition between birds and rodents whose main biological effects are unknown at present, although composition and densities of avian species could be affected. As Janzen (1986) recently expressed, other topics than customary (area, distance to continent, habitat diversity, etc.) are involved in island biology; the ones related to high densities of generalist animals, such as wood mice (Flowerdew 1977; Le Louaran and Saint-Girons 1977), represent an important threat for stenoecious or scarce organisms.

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Zusammenfassung

Ein Experiment zur Ermittlung der Nahrungsaufnahme der Waldmaus (Apodemus sylvaticus) auf Bäumen

Untersucht wurden mehrere Faktoren, die die Aktivitäten von Waldmäusen bei der Nahrungssuche auf Bäumen beeinflussen. Dazu wurden in mehreren Waldparzellen in Zentralspanien während des Winters Eicheln am Boden, an Stämmen und auf Zweigen von 429 Bäumen angeboten. Der Konsum von Eicheln auf Zweigen war positiv und signifikant korreliert mit der Erreichbarkeit der Nahrung, aber nicht mit der Häufigkeit der Waldmäuse. Die Eicheln wurden vornehmlich von Boden und Stämmen aufgenommen, aber auch von Zweigen unterschiedlicher Stärke, allerdings nur bis zu 3,5 m Höhe. Dieses weist auf Grenzen der Art hin, den arboricolen Lebensraum zu nutzen.

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